



## **Biological Assessment Report**

### **Muddy Creek Fall 2015 and Spring 2016 Pettis County, Missouri**

Prepared for the  
Missouri Department of Natural Resources  
Division of Environmental Quality  
Water Protection Program

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- Appendix A    Fall 2015 Macroinvertebrate Taxa Lists, Muddy Creek
- Appendix B    Spring 2016 Macroinvertebrate Taxa Lists, Muddy Creek

## **1.0 Introduction**

Muddy Creek (**MC**) was previously sampled because warm water habitat and the general criteria were suspected of being impaired. In 1992 and 1994, fish kills occurred due to high ammonia levels from the Sedalia Central Wastewater Treatment Plant (**SCWWTP**) (MoDNR 2004). The SCWWTP discharges into Brushy Creek, a tributary of Muddy Creek, in the upstream portion of this study's survey reach. Macroinvertebrate samples were collected in the spring and fall of 1997, and no stations along Muddy Creek had a Macroinvertebrate Stream Condition Index (**MSCI**) score higher than 14. During 1997 a total maximum daily load (**TMDL**) for pollutants was calculated for Muddy Creek to meet water quality standards (MoDNR 2002). In 1998 Muddy Creek was placed on the 303(d) list for high biological oxygen demand (BOD). The SCWWTP upgraded their facility in 1998-2000, and water quality data collected during 2001 and 2003 by the Missouri Department of Natural Resources (**MoDNR**) Environmental Services Program (**ESP**) indicated water quality standards were met. The U.S. Environmental Protection Agency (**EPA**) approved the MoDNR Muddy Creek and Brushy Creek TMDL study on February 11, 2002, and the two streams were removed from the 2002 303(d) List. In 2018 62.2 miles of Muddy Creek were added to the 303(d) list for *Escherichia coli*, the source being rural non-point source pollution. Designated uses for Muddy Creek include warm water habitat, whole body contact recreation category B, secondary contact recreation, human health protection, irrigation, and livestock and wildlife protection (MoDNR 2014).

## **1.1 Purpose of bioassessment study**

The MoDNR Water Protection Program directed the ESP Water Quality Monitoring Section (**WQMS**) to conduct a bioassessment of Muddy Creek during the fall 2015 and spring 2016. Muddy Creek water body identification number (**WBID**) 0853 is a Class P stream (maintains flow throughout the year). This study was conducted to assess whether the warm water habitat designated use is being met as required by the Missouri Water Quality Standards (**WQS**, MoDNR 2014).

## **1.2 Study goals**

The goal of this study was to assess water quality based on stream habitat, water chemistry, and the macroinvertebrate community of Muddy Creek (**MC**) in Pettis County, Missouri. To address this goal, four stations were sampled: one station upstream of the SCWWTP, one station downstream of the SCWWTP but upstream of the Tyson Wastewater Plant (**TWP**), and two stations downstream of TWP (Figure 1). Samples were collected on September 29, 2015, October 1, 2015, and March 28 and 29, 2016. Tasks included the analysis of habitat parameters to compare with reference habitat conditions, water chemistry analyses for comparison to past values and to determine trends related to the biological community, and a bioassessment of the macroinvertebrate community to infer biological integrity.

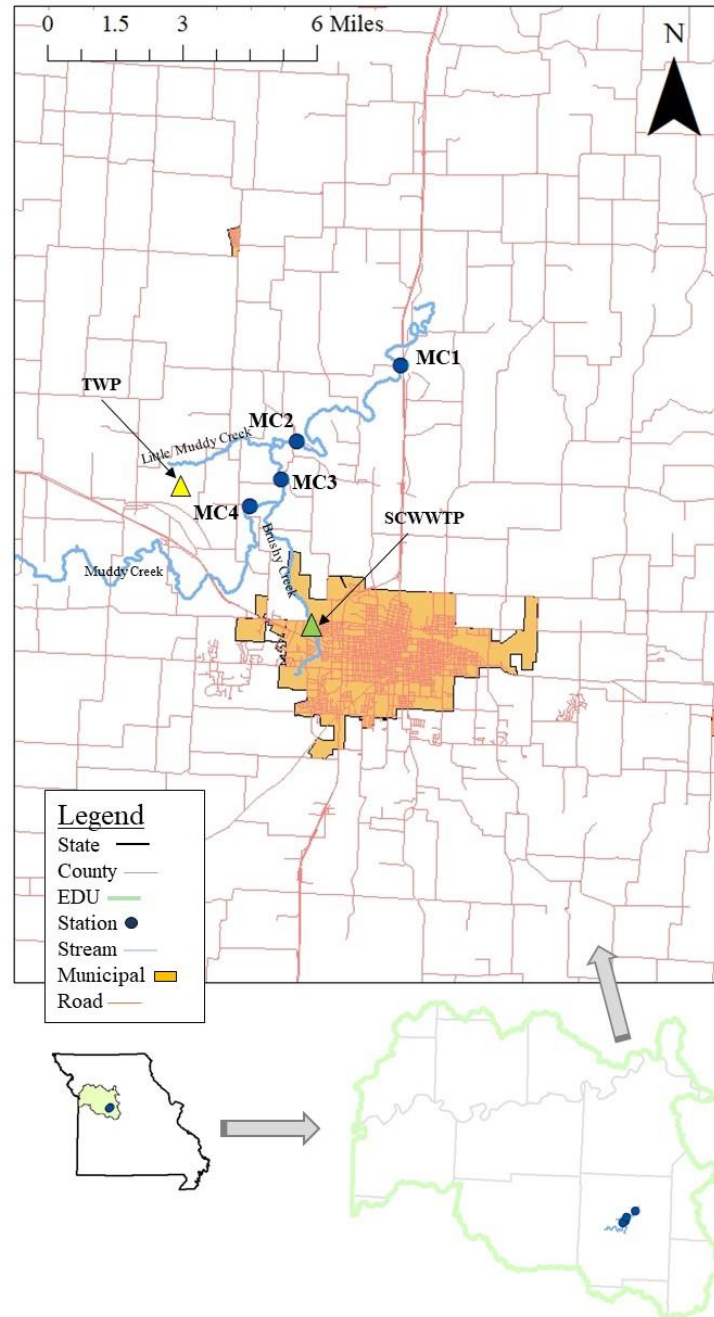


Figure 1. Stations on Muddy Creek, Pettis County, Missouri.

Notes: MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road. EDU = Central Plains/Blackwater/Lamine Ecological Drainage Unit, TWP = Tyson Wastewater Plant, SCWWTP = Sedalia Central Wastewater Treatment Plant.

### 1.3 Null hypotheses

H<sub>1</sub>: Habitat scores will not differ among stations.

H<sub>2</sub>: Muddy Creek habitat scores will not differ from the reference stream habitat.

H<sub>3</sub>: Physicochemical parameters will not differ among stations.

H<sub>4</sub>: Physicochemical water quality parameters will meet Missouri Water Quality Standards (**WQS**).

H<sub>5</sub>: Physicochemical water quality parameters will meet EPA nutrient recommendations.

H<sub>6</sub>: The MSCI will indicate stations are all fully supporting of the protection of warm water habitat beneficial use designation.

### 1.4 Study area

The Muddy Creek drainage is located northwest of Sedalia and mainly consists of cropland and grassland (71.3 percent) (Table 1). Forest cover is lower and impervious surface cover is higher than in the wadeable/perennial biological criteria reference (**BIOREF**) stream, East Fork Crooked Creek drainage (Table 1).

Table 1  
Percent land cover in the Muddy Creek (MC) study drainage in comparison to the reference stream and the Central Plains/Blackwater/Lamine EDU drainage

| Land Cover (percent)         | Hydrologic Unit Code 12     |                                  | Central Plains/<br>Blackwater/<br>Lamine EDU |
|------------------------------|-----------------------------|----------------------------------|----------------------------------------------|
|                              | MC Stations<br>103001030405 | Reference Stream<br>103001010709 |                                              |
| Impervious                   | 4.1                         | 1.9                              | 2.7                                          |
| High Intensity Urban         | 0.8                         | 0                                | 0.7                                          |
| Low Intensity Urban          | 5.0                         | 0                                | 4.5                                          |
| Barren or Sparsely Vegetated | 0.2                         | 0                                | 0.1                                          |
| Cropland                     | 31.5                        | 30                               | 38.2                                         |
| Grassland                    | 39.8                        | 40.1                             | 31.5                                         |
| Deciduous Forest             | 13.7                        | 21.6                             | 15.9                                         |
| Evergreen Forest             | 0                           | 0                                | 0                                            |
| Mixed Forest                 | 0                           | 0                                | 0                                            |
| Deciduous Woody/Herbaceous   | 2.1                         | 3.5                              | 2.1                                          |
| Evergreen Woody/Herbaceous   | 0                           | 0                                | 0                                            |
| Woody-dominated Wetland      | 1.8                         | 2.1                              | 1.9                                          |
| Herbaceous-dominated Wetland | 0.1                         | 0.2                              | 0.6                                          |
| Open Water                   | 0.9                         | 0.5                              | 1.9                                          |

Notes: EDU = ecological drainage unit.

### 1.5 Station descriptions

Muddy Creek Station #1 (**MC1**) (NW¼ sec. 4, T. 46 N., R. 21 W.) was located upstream of the bridge crossing at Smelser Road. Geographic coordinates for this location in Universal Transverse Mercator (**UTM**) coordinates were UTM Zone 15 UTME 480326, UTMN 4294210.

Muddy Creek Station #2 (**MC2**) (NW¼ sec. 18, T. 46 N., R. 21 W.) was located 100 meters upstream and 200 meters downstream of the bridge crossing at Highway H. The sample reach was approximately 0.3 miles downstream of Little Muddy Creek, the receiving stream for the TWP. Geographic coordinates for this location in UTM coordinates were UTM Zone 15 UTME 476585, UTMN 4291481.

Muddy Creek Station #3 (**MC3**) (SW¼ sec. 19, T. 46 N., R. 21 W.) was located upstream of the bridge crossing at Treasure Road. Geographic coordinates for this location in UTM coordinates were UTM Zone 15 UTME 476049, UTMN 4290119.

Muddy Creek Station #4 (**MC4**) (NW¼ sec. 24, T. 46 N., R. 22 W.) was located upstream of the bridge crossing at Yeater Road. This station is upstream of the Brushy Creek confluence, the receiving stream for the SCWWTP. Geographic coordinates for this location in UTM coordinates were UTM Zone 15 UTME 474918, UTMN 4289163.

## **2.0 Methods**

### **2.1 Stream habitat**

Stream habitat is a foundational filter for aquatic communities and as such determines which species can be supported. Stream habitat was assessed using procedures for glide/pool streams in the *Stream Habitat Assessment Project Procedure (SHAPP, MoDNR 2016i)*. Stream bed and bank morphology were assessed using 10 habitat measures: epifaunal substrate cover, pool substrate characterization, pool variability, sediment deposition, channel flow status, channel alteration, channel sinuosity, bank stability, bank vegetative protection, and riparian vegetative zone width. Each habitat measure was scored based on a range between zero and 20, where higher values indicated higher quality habitat conditions. The total habitat score equaled the sum of scores for each habitat measure assessed along 10 separate sections of the stream reach. A stream reach was defined as 20 times the average width of the stream. Scores for each habitat measure were determined by either an average or selection of the predominant category. Study stream habitat scores were compared to the reference stream habitat scores at East Fork Crooked Creek in Ray County. Habitat scores were compared between the study stream and the reference stream. Study stream habitat scores that were  $\geq 75$  percent of the reference stream habitat scores indicated these habitats should be able to support biological communities comparable to the reference stream (MoDNR 2016i).

### **2.2 Stream physicochemistry**

Water chemistry samples were collected from each of the four sampling stations in accordance with the MoDNR Standard Operating Procedure (**SOP**) *Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* (MoDNR 2016h). Water parameters were collected as grab samples and included ammonia as nitrogen, total nitrogen, nitrate + nitrite as nitrogen, total phosphorus, chloride, hardness, non-filterable residue, and sulfate. Additional water quality parameters were collected *in situ*, which included temperature ( $^{\circ}\text{C}$ ) (MoDNR 2016e), specific conductance ( $\mu\text{S cm}^{-1}$ ) (MoDNR 2016b), dissolved oxygen ( $\text{mg L}^{-1}$ )



(MoDNR 2016a), pH (standard units) (MoDNR 2016d), and discharge (cfs) (MoDNR 2015). Turbidity (NTU) (MoDNR 2016c) samples were collected in the field and kept on ice to be measured in the WQMS biology laboratory. All samples were kept on ice and transported to the Chemical Analysis Section (CAS) of ESP in Jefferson City, Missouri. Physicochemical values were compared to Missouri WQS (MoDNR 2014); nutrients and turbidity were compared to the 25th percentile of ecoregion IX as designated by the EPA (USEPA 2000). Nutrient criteria do not currently exist for Missouri; therefore, nutrient concentrations were compared to EPA recommended concentrations for ecoregion IX (USEPA 2000).

### **2.3 Bioassessment**

Muddy Creek was classified as a glide/pool stream, and macroinvertebrate samples were collected from the following three habitats: non-flowing water over depositional substrate (NF), large woody debris (SG), and rootmat substrate (RM). Samples were collected in accordance with the *Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)* (MoDNR 2012). Habitat samples were subsampled under 10 times magnification, and macroinvertebrate specimens were identified to specific taxonomic levels (MoDNR 2016j) in the laboratory.

MSCI scores of MC were calculated using benthic macroinvertebrate subsamples and biological criteria based on BIOREF stream sample data within the Central Plains/Blackwater/Lamine EDU (MoDNR 2012). The MSCI is based on four biological metrics: taxonomic richness (TR); Ephemeroptera, Plecoptera and Trichoptera taxonomic richness (EPTT); biotic index (BI); and the Shannon Diversity Index (SDI). An MSCI score ranging between 16 and 20 is considered “fully supporting,” between 10 and 14 is “partially supporting,” and between 4 and 8 is “non-supporting” of the protection of warm water habitat beneficial use designation as listed in the Missouri WQS (MoDNR 2012). Data were compared within rather than across seasons for the sampling periods in the fall 2015 and spring 2016.

### **2.4 Quality assurance/quality control (QA/QC) of bioassessment data**

#### **2.4.1 Sample collection**

Samples were collected in accordance with *Quality Assurance/Quality Control for Environmental Data Collection* (MoDNR 2013).

#### **2.4.2 Meter calibration**

Field meters necessary for the collection of temperature, turbidity, dissolved oxygen, pH, specific conductance, and discharge were maintained in accordance with *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016f).

#### **2.4.3 Macroinvertebrate subsampling**

Steps to assure accuracy of organism removal from sample debris were performed consistent with those methods in the SMSBPP (MoDNR 2012).

#### 2.4.4 Macroinvertebrate data entry

Macroinvertebrate data were entered into the WQMS macroinvertebrate database in accordance with *Quality Control Procedures for Data Processing* (MoDNR 2016g).

### 3.0 Bioassessment results

#### 3.1 Stream habitat

All Muddy Creek habitat assessment scores were higher than the BIOREF (East Fork Crooked Creek) habitat score (Table 2). Epifaunal substrate cover was higher at MC4 in comparison to remaining stations. Bank stability was highest at MC1 in comparison to remaining stations and the reference. Both stations MC1 and MC2 had higher riparian vegetative zone widths than the other two stations. The BIOREF scored poorer in epifaunal substrate cover, pool substrate characterization, sediment deposition, and vegetative protection than did MC stations. Only channel alteration and channel sinuosity scored higher at the BIOREF site than any MC stations.

Table 2  
Habitat assessment of Muddy Creek (MC) stations, Pettis County, Missouri, during the fall of 2015

| Parameter                       | Station   |           |           |           |           |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|
|                                 | MC1       | MC2       | MC3       | MC4       | Reference |
| Epifaunal substrate cover       | 9         | 11        | 11        | 18        | 7         |
| Pool substrate characterization | 15        | 15        | 13        | 17        | 12        |
| Pool variability                | 14        | 15        | 16        | 15        | 15        |
| Sediment deposition             | 13        | 8         | 10        | 12        | 3         |
| Channel flow status             | 18        | 14        | 19        | 18        | 15        |
| Channel alteration              | 14        | 14        | 17        | 13        | 18        |
| Channel sinuosity               | 7         | 6         | 6         | 6         | 10        |
| Bank stability                  | 17        | 15        | 10        | 15        | 11        |
| Vegetative protection           | 4         | 6         | 4         | 9         | 3         |
| Riparian vegetative zone width  | 16        | 18        | 10        | 9         | 10        |
| Total score                     | 127 (122) | 122 (117) | 116 (112) | 132 (127) | 104       |

Notes: Values in parentheses are percentages of the reference habitat score. MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road. The reference stream was East Fork Crooked Creek in Ray County, Missouri.

#### 3.2 Physicochemical analysis

During the fall 2015 sample season, Muddy Creek nutrient concentrations generally increased in the downstream direction. All physicochemical parameters were within Missouri WQS limits (Table 3). Chloride, conductivity, and flow increased greatly between stations MC4 and MC3. Nitrate + nitrite as nitrogen, total nitrogen, and total phosphorus concentrations were higher than EPA recommended levels at stations MC1, MC2, and MC3.

Spring 2016 physicochemical trends were similar to fall trends. Nutrients increased in the downstream direction (Table 4). Again, a drastic increase in chloride occurred between stations MC4 and MC3. Conductivity increased noticeably between stations MC3 and MC2. Similar to the fall, nitrate + nitrite as nitrogen, total nitrogen, and total phosphorus concentrations were higher than EPA recommended levels at stations MC1, MC2, and MC3. Further, nutrient values were all higher in the fall sampling season than in the spring. Both dissolved oxygen and discharge were lower in the fall than spring season.

Table 3  
Physicochemical and nutrient data in Muddy Creek (MC) study stations, Pettis County, Missouri, during the fall 2015

| Parameter                                    | Station     |             |             |       | EPA recommended values |
|----------------------------------------------|-------------|-------------|-------------|-------|------------------------|
|                                              | MC1         | MC2         | MC3         | MC4   |                        |
| Ammonia (mg L <sup>-1</sup> )                | 0.12        | 0.15        | 0.083       | 0.091 | -                      |
| Calcium (mg L <sup>-1</sup> )                | 59.9        | 50.8        | 60.5        | 44.0  | -                      |
| Chloride (mg L <sup>-1</sup> )               | 232         | 252         | 249         | 12.4  | -                      |
| Dissolved oxygen (mg L <sup>-1</sup> )       | 7.74        | 7.96        | 7.06        | 6.24  | -                      |
| Flow (cfs)                                   | 5.8         | 5.2         | 1.4         | 0.1   | -                      |
| Hardness (mg L <sup>-1</sup> )               | 269         | 247         | 262         | 159   | -                      |
| Magnesium (mg L <sup>-1</sup> )              | 29.1        | 29.1        | 26.9        | 12.0  | -                      |
| pH                                           | 8.3         | 8.4         | 7.8         | 7.9   | -                      |
| Specific conductivity (µS cm <sup>-1</sup> ) | 1511        | 1642        | 1308        | 343   | -                      |
| Sulfate (mg L <sup>-1</sup> )                | 79.4        | 89.0        | 54.8        | 32.7  | -                      |
| Temperature (°C)                             | 17.9        | 14.8        | 19.6        | 21.4  | -                      |
| Total suspended solids (mg L <sup>-1</sup> ) | 12.0        | 7.00        | 7.00        | <5    | -                      |
| Turbidity (NTU)                              | 12          | 8.6         | 7.2         | 3.6   | 15.5                   |
| Total nitrogen (mg L <sup>-1</sup> )         | <b>13.4</b> | <b>19.1</b> | <b>11.0</b> | 0.49  | 0.712                  |
| Nitrate + nitrite as N (mg L <sup>-1</sup> ) | <b>11.7</b> | <b>17.5</b> | <b>10.8</b> | 0.020 | 0.23                   |
| Total phosphorus (mg L <sup>-1</sup> )       | <b>6.47</b> | <b>7.75</b> | <b>4.30</b> | 0.052 | 0.0925                 |

Notes: Values in bold exceed EPA recommended concentrations. Dashes indicate values did not apply. "Less than" values = below detectable limits. MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

Table 4  
Physicochemical and nutrient data in Muddy Creek (MC) study stations, Pettis County, Missouri, during the spring 2016

| Parameter                                    | Station     |             |             |        | EPA recommended values |
|----------------------------------------------|-------------|-------------|-------------|--------|------------------------|
|                                              | MC1         | MC2         | MC3         | MC4    |                        |
| Ammonia (mg L <sup>-1</sup> )                | 0.11        | 0.11        | 0.097       | 0.056  | -                      |
| Calcium (mg L <sup>-1</sup> )                | 66.0        | 53.8        | 66.0        | 66.2   | -                      |
| Chloride (mg L <sup>-1</sup> )               | 90.7        | 86.0        | 43.9        | 21.0   | -                      |
| Dissolved oxygen (mg L <sup>-1</sup> )       | 14.11       | 10.60       | 11.14       | 10.08  | -                      |
| Flow (cfs)                                   | 24.6        | 19.1        | 15.0        | 10.1   | -                      |
| Hardness (mg L <sup>-1</sup> )               | 251         | 208         | 245         | 242    | -                      |
| Magnesium (mg L <sup>-1</sup> )              | 21.0        | 18.0        | 19.4        | 18.7   | -                      |
| pH                                           | 8.9         | 8.6         | 8.5         | 8.3    | -                      |
| Specific conductivity (µS cm <sup>-1</sup> ) | 876         | 763         | 574         | 527    | -                      |
| Sulfate (mg L <sup>-1</sup> )                | 89.6        | 91.5        | 88.1        | 128    | -                      |
| Temperature (°C)                             | 11.0        | 11.1        | 11.6        | 11.5   | -                      |
| Total suspended solids (mg L <sup>-1</sup> ) | 8.00        | 10.0        | 15.0        | 12.0   | -                      |
| Turbidity (NTU)                              | 5.6         | 7.7         | 9.3         | 9.8    | 15.5                   |
| Total nitrogen (mg L <sup>-1</sup> )         | <b>6.61</b> | <b>5.35</b> | <b>2.47</b> | 0.60   | 0.712                  |
| Nitrate + nitrite as N (mg L <sup>-1</sup> ) | <b>5.41</b> | <b>4.16</b> | <b>1.66</b> | <0.008 | 0.23                   |
| Total phosphorus (mg L <sup>-1</sup> )       | <b>1.97</b> | <b>2.31</b> | <b>0.85</b> | 0.054  | 0.0925                 |

Notes: Values in bold exceed EPA recommended concentrations. Dashes indicate were values did not apply. “Less than” values = below detectable limits. MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

### 3.3 Biological assessment

#### 3.3.1 Macroinvertebrate community composition

The Muddy Creek fall macroinvertebrate community composition lacked one pollution-sensitive order, and common taxa included many with higher tolerance values ( $BI \geq 5.0$ ) (Tables 5 and 6). In the fall season, the percentage of EPT taxa was higher at stations MC1 and MC3 than in the remaining stations, and the lowest percentage of EPT was collected at station MC2 (Table 5). The greatest percentage of fall season taxa with a  $BI > 8.9$  was collected from MC3, and the lowest percentage was from MC4 (Table 6). The majority of the macroinvertebrate community had mid-range tolerance values ( $BI = 5.0 - 7.4$ ). The most common tolerant taxa collected from all MC stations in the fall were Tubificidae, *Tanytarsus*, and *Enallagma* (Table 7). Forty-two percent of these common taxa were from the order Diptera, and the only common Trichoptera was *Cheumatopsyche* collected from MC3.

Table 5  
Percentages of Ephemeroptera, Plecoptera, and Trichoptera taxa  
within Muddy Creek, Pettis County, Missouri, during the fall 2015  
season

| Order         | Station |     |      |      |
|---------------|---------|-----|------|------|
|               | MC1     | MC2 | MC3  | MC4  |
| Ephemeroptera | 18.0    | 5.7 | 11.0 | 11.2 |
| Plecoptera    | 0       | 0   | 0    | 0    |
| Trichoptera   | 1.4     | 0.2 | 6.5  | 0.4  |
| Total         | 19.4    | 5.9 | 17.5 | 11.6 |

Notes: MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

Table 6  
Percentage of communities at Muddy Creek belonging to biotic  
index (BI) categories in comparison to the entire Central  
Plains/Blackwater/Lamine EDU during the fall 2015

| BI range  | Station |       |       |       | Fall EDU |
|-----------|---------|-------|-------|-------|----------|
|           | MC1     | MC2   | MC3   | MC4   |          |
| < 2.5     | 0.42    | 0.78  | 0.21  | 0     | 4.54     |
| 2.5 – 4.9 | 5.5     | 2.34  | 1.6   | 3.67  | 2.4      |
| 5.0 – 7.4 | 50.85   | 47.94 | 52.51 | 46    | 38.55    |
| 7.5 – 8.9 | 22.09   | 26.09 | 19.64 | 32.33 | 35.96    |
| > 8.9     | 21.14   | 22.85 | 26.04 | 18    | 18.55    |

Notes: MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

Table 7  
Ten most common taxa (percentage of sample) in Muddy Creek, Pettis  
County, Missouri, during the fall 2015

| Taxon                              | BI  | Station |      |       |       |
|------------------------------------|-----|---------|------|-------|-------|
|                                    |     | MC1     | MC2  | MC3   | MC4   |
| Tubificidae                        | 9.2 | 11.84   | 3.46 | 11.31 | 7.11  |
| <i>Stenacron</i>                   | 7.1 | 10.78   | -    | 5.98  | -     |
| <i>Tribelos</i>                    | 6.6 | 9.3     | -    | -     | -     |
| <i>Tanytarsus</i>                  | 6.7 | 7.19    | 11.4 | 13.98 | 10.44 |
| <i>Stenonema femoratum</i>         | 7.5 | 4.02    | -    | -     | -     |
| <i>Hyalella azteca</i>             | 7.9 | 3.7     | 8.7  | -     | 3.22  |
| <i>Procladius</i>                  | 9.3 | 3.49    | 7.13 | -     | -     |
| <i>Enallagma</i>                   | 9   | 3.28    | 4.35 | 2.99  | 3.78  |
| <i>Argia</i>                       | 8.7 | 3.07    | -    | -     | -     |
| <i>Glyptotendipes</i>              | 8.5 | 2.96    | -    | 3.84  | -     |
| Forcipomyiinae                     | 6   | -       | 8.47 | -     | -     |
| <i>Dicrotendipes</i>               | 7.9 | -       | 7.69 | 3.95  | 3.89  |
| Ancylidae                          | 7.1 | -       | 7.47 | -     | -     |
| <i>Polypedilum illinoense</i> grp. | 9.2 | -       | 4.24 | 4.27  | -     |
| <i>Caenis latipennis</i>           | 7.6 | -       | 2.45 | -     | 4.78  |
| <i>Cheumatopsyche</i>              | 6.6 | -       | -    | 6.51  | -     |
| Acarina                            | 5.7 | -       | -    | 3.52  | 7.67  |
| <i>Stenochironomus</i>             | 6.4 | -       | -    | 2.77  | -     |
| <i>Menetus</i>                     | 8.4 | -       | -    | -     | 4.56  |
| <i>Berosus</i>                     | 8.6 | -       | -    | -     | 3.89  |
| <i>Ablabesmyia</i>                 | 6.4 | -       | -    | -     | 3.78  |

Notes: BI = biotic index value, dashes indicate taxon was not among 10 most common taxa, MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

During the spring, Muddy Creek EPT taxa percentages were all low and increased slightly in the downstream direction (Table 8). Muddy Creek spring season samples had the most tolerant (BI > 8.9) macroinvertebrate taxa at station MC2 (Table 9). As in the fall, most of the macroinvertebrate community had mid-range BI tolerance values. Among the most common taxa found at all MC stations were the Diptera *Tanytarsus*, *Dicrotendipes*, and *Cricotopus/Orthocladius* (Table 10). Unlike in the fall season, two of these common taxa included those with a BI < 5.0. *Cladotanytarsus* (BI = 3.7) and *Eukiefferiella* (BI = 4) were common taxa with low tolerance values collected from at least one of the four MC stations.

Table 8  
Percentages of Ephemeroptera, Plecoptera, and Trichoptera  
taxa within Muddy Creek, Pettis County, Missouri, during  
the spring 2016 season

| Order         | Station |     |     |     |
|---------------|---------|-----|-----|-----|
|               | MC1     | MC2 | MC3 | MC4 |
| Ephemeroptera | 2.5     | 1.4 | 0.7 | 2.3 |
| Plecoptera    | 0       | 0   | 0   | 0   |
| Trichoptera   | 1.1     | 1.3 | 2.0 | 0.3 |
| Total         | 3.6     | 2.7 | 2.7 | 2.6 |

Notes: MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

Table 9  
Percentage of communities at Muddy Creek belonging to biotic  
index (BI) categories in comparison to the entire Central  
Plains/Blackwater/Lamine EDU during the spring 2016

| BI range  | Station |       |       |       | Spring<br>EDU |
|-----------|---------|-------|-------|-------|---------------|
|           | MC1     | MC2   | MC3   | MC4   |               |
| < 2.5     | 0.44    | 0.1   | 0.51  | 0.31  | 2.2           |
| 2.5 – 4.9 | 3.83    | 4.51  | 4.19  | 8.04  | 8.73          |
| 5.0 – 7.4 | 58.69   | 57.34 | 64.56 | 59.66 | 43.52         |
| 7.5 – 8.9 | 21.75   | 18.55 | 14.2  | 15.98 | 18.34         |
| > 8.9     | 15.3    | 19.5  | 16.55 | 15.98 | 27.22         |

Notes: MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

Table 10  
Ten most common taxa (percentage of sample) in Muddy Creek, Pettis  
County, Missouri, during the spring 2016

| Genus                              | BI  | Station |       |       |       |
|------------------------------------|-----|---------|-------|-------|-------|
|                                    |     | MC1     | MC2   | MC3   | MC4   |
| <i>Tanytarsus</i>                  | 6.7 | 17.92   | 9.54  | 10.32 | 9.27  |
| <i>Dicrotendipes</i>               | 7.9 | 12.9    | 9.01  | 6.64  | 4.13  |
| <i>Cricotopus/Orthocladius</i>     | 6.5 | 9.4     | 32.18 | 30.03 | 17.32 |
| <i>Cryptotendipes</i>              | 6.1 | 5.36    | -     | 6.54  | 3.91  |
| <i>Hydrobaenus</i>                 | 9.6 | 5.14    | 9.75  | 2.35  | 4.92  |
| <i>Parakiefferiella</i>            | 5.9 | 4.37    | -     | -     | -     |
| <i>Polypedilum illinoense</i> grp. | 9.2 | 4.26    | 2.73  | -     | -     |
| <i>Thienemannimyia</i> grp.        | 6   | 4.15    | 2.94  | 3.68  | -     |
| Acarina                            | 5.7 | 3.93    | -     | -     | 17.54 |
| <i>Cladotanytarsus</i>             | 3.7 | 3.06    | -     | 3.88  | 4.92  |
| <i>Polypedilum scalaenum</i> grp.  | 8.7 | -       | 2.83  | 2.76  | -     |
| <i>Physella</i>                    | 9.1 | -       | 2.31  | -     | 2.23  |
| <i>Eukiefferiella</i>              | 4   | -       | 2.1   | -     | -     |
| Ceratopogoninae                    | 6   | -       | 1.99  | -     | 2.35  |
| Tubificidae                        | 9.2 | -       | -     | 10.62 | 3.91  |
| <i>Cheumatopsyche</i>              | 6.6 | -       | -     | 1.94  | -     |

Notes: BI = biotic index value, dashes indicate taxon was not among 10 most common taxa, MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

### 3.3.2 Macroinvertebrate Stream Condition Index (MSCI) scores

All Muddy Creek stations attained the highest possible fully supporting MSCI scores in fall 2015 (Tables 11 and 12). Fall TR and EPTT metric values were highest at MC1, the BI was lowest at MC1, and the SDI was highest at MC4 (Table 11).

Table 11  
Metric scores for Muddy Creek, Pettis County, Missouri, during the fall of 2015

| Station | TR     | EPTT   | SDI      | BI      | MSCI score | Interpretation   |
|---------|--------|--------|----------|---------|------------|------------------|
| MC1     | 73 (5) | 12 (5) | 3.44 (5) | 7.3 (5) | 20         | Fully supporting |
| MC2     | 61 (5) | 7 (5)  | 3.33 (5) | 7.4 (5) | 20         | Fully supporting |
| MC3     | 67 (5) | 7 (5)  | 3.38 (5) | 7.5 (5) | 20         | Fully supporting |
| MC4     | 72 (5) | 7 (5)  | 3.54 (5) | 7.4 (5) | 20         | Fully supporting |

Notes: TR = taxonomic richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera richness, SDI = Shannon Diversity Index, BI = Biotic Index, MSCI = Macroinvertebrate Stream Condition Index, Values in () are individual metric scores, MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.



Table 12  
Metric score calculation boundaries at Muddy Creek, Pettis County,  
Missouri, during the fall 2015

| Metric score | TR                  | EPTT              | SDI                     | BI                    |
|--------------|---------------------|-------------------|-------------------------|-----------------------|
| 5            | $x > 55$            | $x > 6$           | $x > 2.85$              | $x < 7.6$             |
| 3            | $27 \leq x \leq 55$ | $3 \leq x \leq 6$ | $1.43 \leq x \leq 2.85$ | $8.8 \geq x \geq 7.6$ |
| 1            | $x < 27$            | $x < 3$           | $x < 1.43$              | $x > 8.8$             |

Notes: TR = taxonomic richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxonomic richness, SDI = Shannon Diversity Index, BI = Biotic Index.

Although spring 2016 Muddy Creek MSCI scores were slightly lower than the fall, all MC stations attained fully supporting scores (Tables 13 and 14). Spring MSCI scores were slightly lower than the fall due to the EPTT metric (Table 13), which had a score of three at all stations. The TR and SDI metric values were highest at MC4, and the BI was lowest at station MC4. Taxonomic richness was lowest at station MC2 during both seasons.

Table 13  
Metric scores for Muddy Creek, Pettis County, Missouri, during the spring of 2016

| Station | TR     | EPTT  | SDI      | BI      | MSCI score | Interpretation   |
|---------|--------|-------|----------|---------|------------|------------------|
| MC1     | 66 (5) | 8 (3) | 3.13 (5) | 7.1 (5) | 18         | Fully supporting |
| MC2     | 64 (5) | 8 (3) | 2.78 (5) | 7.2 (5) | 18         | Fully supporting |
| MC3     | 70 (5) | 8 (3) | 2.79 (5) | 7.0 (5) | 18         | Fully supporting |
| MC4     | 77 (5) | 5 (3) | 3.14 (5) | 6.8 (5) | 18         | Fully supporting |

Notes: TR = taxonomic richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxonomic richness, SDI = Shannon Diversity Index, BI = Biotic Index, MSCI = Macroinvertebrate Stream Condition Index, Values in () are individual metric scores, MC1 = station upstream of bridge crossing at Smelser Road, MC2 = station 100 meters upstream and 200 meters downstream of bridge crossing at Hwy H, MC3 = station upstream of bridge crossing at Treasure Road, MC4 = station upstream of bridge crossing at Yeater Road.

Table 14  
Metric score calculation boundaries at Muddy Creek, Pettis County,  
Missouri, during the spring 2016

| Metric score | TR                  | EPTT              | SDI                     | BI                    |
|--------------|---------------------|-------------------|-------------------------|-----------------------|
| 5            | $x > 50$            | $x > 8$           | $x > 2.53$              | $x < 7.3$             |
| 3            | $25 \leq x \leq 50$ | $4 \leq x \leq 8$ | $1.27 \leq x \leq 2.53$ | $8.7 \geq x \geq 7.3$ |
| 1            | $x < 25$            | $x < 4$           | $x < 1.27$              | $x > 8.7$             |

Notes: TR = taxonomic richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxonomic richness, SDI = Shannon Diversity Index, BI = Biotic Index.

### 3.3.3. Comparison of macroinvertebrate community to 1997 fall samples

Previous macroinvertebrate samples collected from Muddy Creek had lower TR, EPTT, and SDI metrics, a higher BI metric, and lower percentages of sensitive orders (Table 15). Taxonomic richness and EPTT values both doubled from fall 1997 to fall 2015 samples (Table 14). Further, macroinvertebrate community evenness (SDI) was higher in 2015 than in 1997, and the BI decreased. Among the three most sensitive orders, the percentage of Ephemeroptera increased slightly from 1997. Whereas Trichoptera was uncollected in the fall 1997, this order made up 6.5 percent of the fall 2015 macroinvertebrate sample (Table 15).

Table 15  
Biological parameter comparison between  
the fall 1997 and fall 2015 at station MC3 of  
Muddy Creek, Pettis County, Missouri

| Parameter         | Station MC3 |      |
|-------------------|-------------|------|
|                   | 1997        | 2015 |
| TR                | 33          | 67   |
| EPTT              | 3           | 7    |
| BI                | 8.4         | 7.5  |
| SDI               | 2.44        | 3.38 |
| MSCI              | 10          | 20   |
| Ephemeroptera (%) | 9.3         | 11   |
| Plecoptera (%)    | 0           | 0    |
| Trichoptera (%)   | 0           | 6.5  |

Notes: TR = taxonomic richness, EPTT = Ephemeroptera, Plecoptera, and Trichoptera taxonomic richness, SDI = Shannon Diversity Index, BI = Biotic Index. MC3 = station upstream of bridge crossing at Treasure Road.

Macroinvertebrate tolerance at station MC3 has shifted over time. Overall, the percentage of macroinvertebrates with mid-range tolerance values (BI = 5.0 – 7.4) increased in the fall 2015 sample in comparison to fall 1997, and those with very high BI values (BI > 8.9) decreased (Table 16). A larger percentage of the fall 2015 macroinvertebrate community included those with a BI < 5.0 (4.7 percent) in comparison to fall 1997 (0.99 percent).

Table 16  
Biological index (BI) comparison between the  
fall 1997 and fall 2015 time periods at station  
MC3 of Muddy Creek, Pettis County, Missouri

| BI value (%) | Station |       |
|--------------|---------|-------|
|              | 1997    | 2015  |
| < 2.5        | 0.99    | 0.51  |
| 2.5 – 4.9    | 0       | 4.19  |
| 5.0 – 7.4    | 24.46   | 64.56 |
| 7.5 – 8.9    | 12.43   | 14.2  |
| > 8.9        | 66.13   | 16.55 |

Notes: MC3 = station upstream of bridge crossing at  
Treasure Road.

## 4.0 Discussion

### 4.1 Stream habitat

Overall, habitat assessment scores were high in comparison to the East Fork Crooked Creek BIOREF site; therefore, Muddy Creek habitat categories are well within the range of what was regionally expected. Some parameters were poor among all MC stations, had a longitudinal trend, or were station specific. Vegetative protection was poor among all MC stations, which can affect food resources, nutrients (Heatherly et al. 2007, Menninger and Palmer 2007), and even macroinvertebrate life history characteristics (Sweeney 1993). Nutrient inundation can result from streams with poor vegetative protection, leading to a stream acting as a nutrient source with a long nutrient cycle distance (Young et al. 2008, Marti et al. 2004). Vegetative protection scored best at MC4, which also had the lowest nutrient levels and is consistent with Young et al. (2008) and Marti et al. (2004). Furthermore, MC4 had the best macroinvertebrate community evenness, showing that vegetative protection likely supports a more diverse stream community (Heatherly et al. 2007). It is also important to note, however, that MC4 is upstream of the influence from Brushy Creek, which receives effluent from the SCWWTP.

Interestingly, MC1 and MC2 had the best riparian zone widths, which should aid in nutrient filtration and retention. However, both these stations had high concentrations of total nitrogen, nitrate + nitrite as nitrogen, and total phosphorus, indicating smaller components of cover like vegetative protection may be just as important to consider as riparian zone width. Additionally, Roth et al. (1996) noted that upstream land use and nutrient input can overwhelm habitat benefits provided by riparian cover.

Within Muddy Creek, epifaunal substrate and sediment deposition categories were poor at some stations. In instances of heavy sediment deposition, the abundance of epifaunal substrate available for macroinvertebrate use can be affected. Specifically, poor substrate quality will decrease EPTT (Richards et al. 1993). Surprisingly, EPTT did not decrease among MC stations downstream but rather increased slightly. All macroinvertebrate metrics are negatively affected by increased sedimentation (Matthaei et al. 2010,

Wagenhoff et al 2012). Sediment deposition scores were particularly poor at station MC2 where EPTT and SDI were lowest during both sample seasons. However, the BIOREF stream had an even lower sediment deposition score (score = 3) in comparison to MC2 (score = 8), indicating deposition is high throughout regional streams.

Among all the variables discussed here (epifaunal substrate cover, sediment deposition, and vegetative protection), lower scores were found in the BIOREF stream, emphasizing how common such stream characteristics are in the Central Plains/Blackwater/Lamine EDU.

#### **4.2 Physicochemical analysis**

Nutrient concentrations were extremely high in Muddy Creek downstream of station MC4, exceeding EPA recommended values (USEPA 2000) in both sample seasons. High nutrients have historically decreased macroinvertebrate community diversity (Delong and Bunsven 1998), and Muddy Creek SDI values followed this observation by being slightly lower among stations downstream of MC4 during both seasons. In contrast to the SDI metric, the BI, which is intended to be a measure of organic pollution, showed only a slight response downstream of MC4 in the spring and none in the fall. In an Ozark region study, Justus et al. (2010) developed biological indices based on algae, macroinvertebrate, and fish communities. In areas of poultry and cattle farms, these indices were much lower where high nutrient concentrations existed. It is worth noting that what Justus et al. (2010) considered to be elevated nutrients were far lower than those measured in Muddy Creek. Streams in the Justus et al. study (2010) had maximum total nitrogen of 4.71 mg L<sup>-1</sup> and maximum total phosphorus of 0.062 mg L<sup>-1</sup>, and Muddy Creek maxima concentrations of total nitrogen and total phosphorus were 19.1 mg L<sup>-1</sup> and 7.75 mg L<sup>-1</sup>, respectively. Algal blooms and subsequent hypoxia are increasing concerns linked with high nitrogen and phosphorus (Black et al. 2011). Algae thrive in the agricultural areas of Washington and Nebraska, and the nutrient concentrations reported by Black et al. (2011) were in the same range as nutrient concentrations collected from Muddy Creek. Despite high levels of total nitrogen, nitrate + nitrite as nitrogen, and total phosphorus, dissolved oxygen and ammonia were in compliance with Missouri WQS.

Several water chemistry parameters increased greatly between stations MC4 and MC3, including chloride and conductivity. These differences appear to correspond to increases in flow between these stations due to input from Brushy Creek, which is the receiving system for the SCWWTP. Nutrients, as discussed previously, also increased between these stations and were beyond the recommended levels set by the EPA (USEPA 2000).

#### **4.3 Biological assessment**

##### **4.3.1 Macroinvertebrate community composition and MSCI scores**

In agricultural streams with high nutrient concentrations, notable decreases in macroinvertebrate diversity have occurred (Delong and Brusven 1998), and a similar decline in SDI was observed in this study. In Muddy Creek, stations downstream of the

SCWWTP and TWP had lower SDI and higher BI metric values in at least one season. Further, SDI was highest during both seasons at the most upstream station (MC4), which suggests potential effects from effluent. Impairment from wastewater treatment facilities has been measured using pollution tolerance in the BI metric (Graham et al. 2010). In a USGS study of a treatment facility in Kansas City, Missouri, areas downstream of the plant had more tolerant taxa (Graham et al. 2010). In Muddy Creek, the percentage of macroinvertebrates with BI >8 was highest at MC3 (downstream of the SCWWTP) and downstream of MC2 (downstream of TWP), depending upon the sample season. In work by Ortiz and Puig (2007), wastewater treatment plant effluent significantly decreased TR and EPTT in conjunction with decreased dissolved oxygen. However, dissolved oxygen declines like those in the Ortiz and Puig (2007) study were not observed in Muddy Creek, which may help to explain why TR and EPTT remained consistent throughout the study reach. Despite fluctuations in biological metric values among Muddy Creek stations, each of the metrics attained the highest possible score during both seasons, with the exception of EPTT in the spring.

#### **4.3.2. Comparison of macroinvertebrate community to 1997 fall sampling event**

All Muddy Creek macroinvertebrate metrics showed improvement when comparing fall 1997 and fall 2015 samples. These changes indicate that substantial biological improvements have occurred, especially in relation to sensitivity and diversity. The SCWWTP facility was upgraded between 1998-2000 to improve low dissolved oxygen levels and high ammonia issues (MoDNR 2004). Both these water quality parameters have drastically improved as has the macroinvertebrate community, which improved from an MSCI score of 10 at station MC3 in the fall 1997 to a score of 20 in fall 2015. Ammonia, total phosphorus, nitrate + nitrite as nitrogen, and total nitrogen concentrations have fluctuated in the years MoDNR has collected samples from MC3. These nutrients have not consistently improved through the years, which suggests that these constituents may be of continued concern. Nutrient concentrations exceeded levels documented downstream of a wastewater treatment facility in Kansas City, Missouri (Graham et al. 2010). Despite these nutrient concerns, the macroinvertebrate community has improved as measured by increased diversity and the presence of pollution-sensitive taxa.

#### **4.4 Conclusions**

Muddy Creek had a fully supporting macroinvertebrate community as indicated by the biological metric scores. Muddy Creek stations had higher total nitrogen, nitrite + nitrate as nitrogen, and total phosphorus concentrations compared to EPA recommended levels (USEPA 2000). Stream habitat scores of all Muddy Creek stations exceeded the score from East Fork Crooked River, a BIOREF stream.

Tests of null hypotheses resulted in the following conclusions.

H<sub>1</sub>: Habitat scores will not differ among stations.

This hypothesis was not supported. Stations differed as much as 16 points from one another with the largest difference between station MC4 (score = 132) and station MC3 (score = 116).

H<sub>2</sub>: Muddy Creek habitat scores will not differ from the reference stream habitat. This hypothesis was not supported. All MC stations scored higher than the biological reference stream habitat.

H<sub>3</sub>: Physicochemical parameters will not differ among stations. This hypothesis was not supported. MC stations differed between MC4 and the downstream stations in nutrients, flow, pH, conductivity, chloride, and turbidity.

H<sub>4</sub>: Physicochemical water quality parameters will meet Missouri Water Quality Standards (WQS). This hypothesis was supported. All parameters met Missouri WQS.

H<sub>5</sub>: Physicochemical water quality parameters will meet EPA nutrient recommendations. This hypothesis was not supported. Total nitrogen, nitrate + nitrite as nitrogen, and total phosphorus were higher than EPA recommended concentrations at stations MC1, MC2, and MC3.

H<sub>6</sub>: The MSCI will indicate stations are all fully supporting of the protection of warm water habitat beneficial use designation. This hypothesis was supported. All MC stations had MSCI scores indicating a fully supporting biotic community.

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## **Appendix A**

Fall 2015 Macroinvertebrate Taxa Lists

Muddy Creek

Semi-quantitative kick net collections of macroinvertebrates from Muddy Creek station 1 (MC1), Pettis County, Missouri in the fall 2015. \* = taxon found in large and rare;

Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

| Taxa                            | Habitat |    |    |
|---------------------------------|---------|----|----|
|                                 | NF      | RM | SG |
| "HYDRACARINA"                   |         |    |    |
| Acarina                         | 8       | 5  | 2  |
| AMPHIPODA                       |         |    |    |
| <i>Hyalella azteca</i>          |         | 34 | 1  |
| ARHYNCHOBDELLIDA                |         |    |    |
| Erpobdellidae                   | 4       | 1  |    |
| BASOMMATOPHORA                  |         |    |    |
| Ancylidae                       | 2       | 9  |    |
| <i>Menetus</i>                  |         | 27 |    |
| <i>Physella</i>                 |         | 2  |    |
| COLEOPTERA                      |         |    |    |
| <i>Ancyronyx variegatus</i>     |         | 11 | 12 |
| <i>Berosus</i>                  |         | 1  | 2  |
| <i>Dubiraphia</i>               | 3       | 5  |    |
| <i>Macronychus glabratus</i>    |         | 1  | 2  |
| Scirtidae                       |         | 21 | 1  |
| <i>Stenelmis</i>                | 1       | 15 |    |
| DECAPODA                        |         |    |    |
| <i>Faxonius luteus</i>          | 1       |    |    |
| <i>Faxonius virilis</i>         | 1       | 1  |    |
| <i>Palaemonetes kadiakensis</i> |         | *  |    |
| DIPTERA                         |         |    |    |
| <i>Ablabesmyia</i>              | 6       |    | 2  |
| <i>Anopheles</i>                |         | 2  | 2  |
| <i>Axarus</i>                   | 1       |    |    |
| Ceratopogoninae                 | 1       |    | 2  |
| Chironomidae                    | 4       | 1  |    |
| <i>Chironomus</i>               | 5       |    |    |
| <i>Cladotanytarsus</i>          | 4       |    | 2  |
| <i>Corynoneura</i>              | 1       | 5  |    |
| <i>Cricotopus/Orthocladius</i>  | 1       |    | 5  |
| <i>Cryptochironomus</i>         | 5       |    | 1  |
| <i>Dicrotendipes</i>            |         |    | 6  |
| Forcipomyiinae                  |         | 2  | 5  |
| <i>Glyptotendipes</i>           | 2       | 8  | 18 |
| <i>Harnischia</i>               | 2       |    |    |
| <i>Labrundinia</i>              |         | 6  |    |
| <i>Limonia</i>                  |         |    | 2  |

| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| <i>Microtendipes</i>              | 3       |    |    |
| <i>Paralauterborniella</i>        | 2       |    |    |
| <i>Paratanytarsus</i>             | 3       | 4  |    |
| <i>Paratendipes</i>               |         |    | 1  |
| <i>Polypedilum fallax</i> grp     |         |    | 2  |
| <i>Polypedilum illinoense</i> grp | 1       | 7  | 1  |
| <i>Polypedilum scalaenum</i> grp  | 2       |    | 1  |
| <i>Procladius</i>                 | 32      | 1  |    |
| <i>Pseudochironomus</i>           |         |    | 27 |
| <i>Rheotanytarsus</i>             |         |    | 1  |
| <i>Stelechomyia</i>               |         | 1  | 10 |
| <i>Stempellina</i>                | 1       |    |    |
| <i>Stempellinella</i>             | 1       |    |    |
| <i>Stenochironomus</i>            |         |    | 13 |
| <i>Stictochironomus</i>           | 2       |    | 18 |
| <i>Tanytarsus</i>                 | 20      | 17 | 31 |
| <i>Thienemannimyia</i> grp.       | 1       | 3  | 4  |
| <i>Tribelos</i>                   |         | 1  | 87 |
| EPHEMEROPTERA                     |         |    |    |
| <i>Acerpenna</i>                  |         |    | 4  |
| <i>Baetis</i>                     |         |    | 1  |
| <i>Caenis latipennis</i>          | 10      | 2  | 2  |
| <i>Centroptilum</i>               | 4       |    |    |
| <i>Hexagenia limbata</i>          | *       |    |    |
| <i>Procloeon</i>                  | 1       |    | 3  |
| <i>Stenacron</i>                  | 61      | 20 | 21 |
| <i>Stenonema femoratum</i>        | 38      |    |    |
| <i>Tricorythodes</i>              |         | 1  | 2  |
| HEMIPTERA                         |         |    |    |
| <i>Belostoma</i>                  |         | *  |    |
| <i>Microvelia</i>                 |         |    | 2  |
| <i>Neoplea</i>                    |         |    | 1  |
| ISOPODA                           |         |    |    |
| <i>Lirceus</i>                    |         | 2  |    |
| LUMBRICINA                        |         |    |    |
| <i>Lumbricina</i>                 |         | 2  |    |
| NEOTAENIOGLOSSA                   |         |    |    |
| Hydrobiidae                       | 1       |    |    |
| ODONATA                           |         |    |    |
| <i>Argia</i>                      |         | 28 | 1  |
| <i>Basiaeschna janata</i>         |         |    | *  |

| Taxa                  | Habitat |    |    |
|-----------------------|---------|----|----|
|                       | NF      | RM | SG |
| <i>Enallagma</i>      | 1       | 28 | 2  |
| TRICHOPTERA           |         |    |    |
| <i>Cheumatopsyche</i> |         |    | 11 |
| <i>Chimarra</i>       |         | 1  |    |
| <i>Hydroptila</i>     | 1       |    |    |
| TUBIFICIDA            |         |    |    |
| <i>Aulodrilus</i>     |         |    | 2  |
| Tubificidae           | 110     | 2  |    |
| VENEROIDA             |         |    |    |
| Pisidiidae            | 2       | 7  |    |

Semi-quantitative kick net collections of macroinvertebrates from Muddy Creek station 2 (MC2), Pettis County, Missouri in the fall 2015. \* = taxon found in large and rare;

Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

| Taxa                             | Habitat |    |    |
|----------------------------------|---------|----|----|
|                                  | NF      | RM | SG |
| "HYDRACARINA"                    |         |    |    |
| Acarina                          | 9       | 1  |    |
| AMPHIPODA                        |         |    |    |
| <i>Hyalella azteca</i>           |         | 74 | 4  |
| ARHYNCHOBDELLIDA                 |         |    |    |
| Erpobdellidae                    | *       |    |    |
| BASOMMATOPHORA                   |         |    |    |
| Ancylidae                        | 3       | 60 | 4  |
| <i>Menetus</i>                   |         | 11 |    |
| <i>Physella</i>                  | 2       | 6  | 3  |
| COLEOPTERA                       |         |    |    |
| <i>Ancyronyx variegatus</i>      |         | 8  | 5  |
| <i>Dubiraphia</i>                | 8       | 8  |    |
| <i>Peltodytes</i>                | 1       | 1  | 1  |
| Scirtidae                        |         | 1  | 7  |
| <i>Stenelmis</i>                 | 1       | 5  |    |
| DIPTERA                          |         |    |    |
| <i>Ablabesmyia</i>               | 7       | 4  | 5  |
| Ceratopogoninae                  | 1       |    | 3  |
| Chironomidae                     | 3       |    |    |
| <i>Chironomus</i>                | 13      |    |    |
| <i>Cladotanytarsus</i>           | 14      |    |    |
| <i>Corynoneura</i>               | 3       | 2  |    |
| <i>Cricotopus/Orthocladius</i>   | 1       | 3  |    |
| <i>Cryptochironomus</i>          | 5       | 1  |    |
| <i>Cryptotendipes</i>            | 2       |    | 1  |
| Dasyheleinae                     |         |    | 1  |
| <i>Dicrotendipes</i>             | 22      | 16 | 31 |
| Forcipomyiinae                   | 1       |    | 75 |
| <i>Glyptotendipes</i>            |         | 2  | 1  |
| <i>Labrundinia</i>               | 2       | 8  | 1  |
| <i>Limonia</i>                   |         |    | 6  |
| <i>Nanocladius</i>               | 1       | 1  |    |
| <i>Paralauterborniella</i>       | 1       |    |    |
| <i>Paratanytarsus</i>            | 1       | 17 | 2  |
| <i>Paratendipes</i>              |         |    | 1  |
| <i>Polypedilum flavum</i>        | 1       |    |    |
| <i>Polypedilum halterale</i> grp | 3       |    |    |

| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| <i>Polypedilum illinoense</i> grp | 2       | 2  | 34 |
| <i>Polypedilum scalaenum</i> grp  | 2       |    | 1  |
| <i>Procladius</i>                 | 61      |    | 3  |
| <i>Pseudochironomus</i>           | 1       |    | 4  |
| <i>Stempellina</i>                | 7       |    |    |
| <i>Stenochironomus</i>            |         | 3  | 5  |
| <i>Tanypus</i>                    | 3       |    |    |
| <i>Tanytarsus</i>                 | 27      | 44 | 28 |
| <i>Thienemanniella</i>            |         | 3  |    |
| <i>Thienemannimyia</i> grp.       |         | 1  | 18 |
| <i>Tribelos</i>                   |         |    | 15 |
| EPHEMEROPTERA                     |         |    |    |
| <i>Baetis</i>                     |         |    | 1  |
| <i>Caenis latipennis</i>          | 17      | 1  | 4  |
| <i>Proclaeon</i>                  | 4       | 1  | 1  |
| <i>Stenacron</i>                  | 4       | 3  | 8  |
| <i>Stenonema femoratum</i>        | 4       |    | 3  |
| HEMIPTERA                         |         |    |    |
| Corixidae                         | 1       |    | 1  |
| <i>Microvelia</i>                 |         |    | 1  |
| <i>Rhagovelia</i>                 |         |    | 1  |
| <i>Rheumatobates</i>              |         | 1  |    |
| <i>Trepobates</i>                 |         |    | 1  |
| NEOTAENIOGLOSSA                   |         |    |    |
| Hydrobiidae                       | 1       |    |    |
| ODONATA                           |         |    |    |
| <i>Argia</i>                      |         | 12 |    |
| <i>Enallagma</i>                  | 1       | 37 | 1  |
| TRICHOPTERA                       |         |    |    |
| <i>Hydropsyche</i>                |         |    | 1  |
| Hydroptilidae                     |         |    | 1  |
| TRICLADIDA                        |         |    |    |
| Planariidae                       |         | 1  |    |
| TUBIFICIDA                        |         |    |    |
| Tubificidae                       | 30      |    | 1  |
| VENEROIDA                         |         |    |    |
| Pisidiidae                        | 5       |    |    |



Semi-quantitative kick net collections of macroinvertebrates from Muddy Creek station 3 (MC3), Pettis County, Missouri in the fall 2015. \* = taxon found in large and rare;

Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

| Taxa                           | Habitat |    |    |
|--------------------------------|---------|----|----|
|                                | NF      | RM | SG |
| "HYDRACARINA"                  |         |    |    |
| Acarina                        | 28      | 2  | 3  |
| AMPHIPODA                      |         |    |    |
| <i>Hyaella azteca</i>          |         | 5  | 1  |
| ARHYNCHOBDELLIDA               |         |    |    |
| Erpobdellidae                  | *       |    |    |
| BASOMMATOPHORA                 |         |    |    |
| Ancylidae                      | 1       | 4  | 6  |
| <i>Menetus</i>                 |         | 24 |    |
| <i>Physella</i>                |         | 16 | 5  |
| BRANCHIOBDELLIDA               |         |    |    |
| Branchiobdellida               |         |    | 1  |
| COLEOPTERA                     |         |    |    |
| <i>Ancyronyx variegatus</i>    |         | 7  | 2  |
| <i>Berosus</i>                 |         |    | 5  |
| <i>Dubiraphia</i>              |         | 5  |    |
| <i>Macronychus glabratus</i>   |         |    | 1  |
| Scirtidae                      |         | 6  | 2  |
| <i>Stenelmis</i>               | 1       | 8  |    |
| DECAPODA                       |         |    |    |
| <i>Faxonius luteus</i>         | 1       |    |    |
| <i>Faxonius virilis</i>        | 1       | *  | *  |
| DIPTERA                        |         |    |    |
| <i>Ablabesmyia</i>             | 4       |    | 1  |
| Ceratopogoninae                | 1       |    | 1  |
| Chironomidae                   | 1       | 1  | 2  |
| <i>Chironomus</i>              | 18      |    |    |
| <i>Corynoneura</i>             |         | 1  |    |
| <i>Cricotopus/Orthocladius</i> |         |    | 3  |
| <i>Cryptochironomus</i>        | 3       |    |    |
| <i>Cryptotendipes</i>          | 1       |    |    |
| <i>Dicrotendipes</i>           | 7       |    | 30 |
| Forcipomyiinae                 |         |    | 15 |
| <i>Glyptotendipes</i>          | 3       | 9  | 24 |
| <i>Mesosmittia</i>             |         |    | 1  |
| <i>Microtendipes</i>           |         |    | 1  |
| <i>Nanocladius</i>             |         | 1  |    |
| <i>Parachironomus</i>          |         | 1  |    |

| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| <i>Paratanytarsus</i>             | 1       | 8  | 2  |
| <i>Polypedilum fallax</i> grp     |         |    | 1  |
| <i>Polypedilum flavum</i>         |         | 7  | 1  |
| <i>Polypedilum illinoense</i> grp | 1       | 19 | 20 |
| <i>Polypedilum scalaenum</i> grp  |         |    | 3  |
| <i>Procladius</i>                 | 24      |    |    |
| <i>Pseudochironomus</i>           |         |    | 4  |
| <i>Rheotanytarsus</i>             |         | 5  | 6  |
| <i>Stelechomyia</i>               |         |    | 1  |
| <i>Stenochironomus</i>            |         |    | 26 |
| <i>Tanypus</i>                    | 1       |    |    |
| <i>Tanytarsus</i>                 | 12      | 20 | 99 |
| <i>Thienemannimyia</i> grp.       |         | 4  | 20 |
| <i>Tribelos</i>                   | 1       |    | 24 |
| EPHEMEROPTERA                     |         |    |    |
| <i>Acerpenna</i>                  |         | 1  | 8  |
| <i>Baetis</i>                     |         | 1  | 1  |
| <i>Caenis latipennis</i>          | 3       |    | 5  |
| <i>Centroptilum</i>               | 2       |    | 1  |
| <i>Stenacron</i>                  | 39      | 1  | 16 |
| <i>Stenonema femoratum</i>        | 24      |    | 1  |
| HEMIPTERA                         |         |    |    |
| <i>Microvelia</i>                 |         | 2  |    |
| <i>Rheumatobates</i>              | 1       | 1  |    |
| <i>Trepobates</i>                 | 1       |    | 1  |
| LUMBRICINA                        |         |    |    |
| <i>Lumbricina</i>                 | *       | 1  |    |
| NEOTAENIOGLOSSA                   |         |    |    |
| Hydrobiidae                       |         | 3  | 4  |
| ODONATA                           |         |    |    |
| <i>Argia</i>                      | 1       | 7  | 3  |
| <i>Dromogomphus</i>               | 1       |    |    |
| <i>Enallagma</i>                  |         | 28 |    |
| TRICHOPTERA                       |         |    |    |
| <i>Cheumatopsyche</i>             |         | 46 | 15 |
| TRICLADIDA                        |         |    |    |
| Planariidae                       |         | 4  |    |
| TUBIFICIDA                        |         |    |    |
| <i>Aulodrilus</i>                 | 3       |    |    |
| <i>Ilyodrilus templetoni</i>      | 1       |    |    |
| <i>Limnodrilus claparedianus</i>  | 2       |    |    |

| Taxa                            | Habitat |    |    |
|---------------------------------|---------|----|----|
|                                 | NF      | RM | SG |
| <i>Limnodrilus hoffmeisteri</i> | 1       |    |    |
| Tubificidae                     | 104     |    | 2  |
| VENEROIDA                       |         |    |    |
| <i>Corbicula</i>                | 1       | 3  |    |
| Pisidiidae                      | 2       | 7  | 15 |

Semi-quantitative kick net collections of macroinvertebrates from Muddy Creek station 4 (MC4), Pettis County, Missouri in the fall 2015. \* = taxon found in large and rare;

Habitats: CS = coarse substrate, NF = nonflow, RM = rootmat.

| Taxa                         | Habitat |    |    |
|------------------------------|---------|----|----|
|                              | NF      | RM | SG |
| "HYDRACARINA"                |         |    |    |
| Acarina                      | 49      | 12 | 8  |
| AMPHIPODA                    |         |    |    |
| <i>Hyalella azteca</i>       |         | 20 | 9  |
| ARHYNCHOBDELLIDA             |         |    |    |
| Erpobdellidae                | 4       |    |    |
| BASOMMATOPHORA               |         |    |    |
| Ancylidae                    | 7       | 7  |    |
| <i>Menetus</i>               |         | 41 |    |
| <i>Physella</i>              | 2       | 12 |    |
| COLEOPTERA                   |         |    |    |
| <i>Ancyronyx variegatus</i>  |         | 3  | 10 |
| <i>Berosus</i>               | 5       | 2  | 28 |
| <i>Dubiraphia</i>            | 2       | 5  | 1  |
| <i>Macronychus glabratus</i> |         |    | 9  |
| Scirtidae                    |         | 4  | 5  |
| <i>Stenelmis</i>             | 1       | 16 |    |
| DECAPODA                     |         |    |    |
| <i>Faxonius luteus</i>       | *       |    |    |
| <i>Faxonius virilis</i>      |         | *  |    |
| DIPTERA                      |         |    |    |
| <i>Ablabesmyia</i>           | 16      | 12 | 6  |
| <i>Antocha</i>               |         |    | 1  |
| Ceratopogoninae              | 2       |    | 1  |
| <i>Chaoborus</i>             | 3       |    |    |
| Chironomidae                 | 1       | 1  | 1  |
| <i>Chironomus</i>            | 12      |    |    |
| <i>Cladotanytarsus</i>       |         |    | 1  |
| <i>Clinotanypus</i>          |         |    | 1  |
| <i>Cryptochironomus</i>      | 5       |    |    |
| <i>Cryptotendipes</i>        | 1       |    | 1  |
| <i>Dicrotendipes</i>         | 8       | 3  | 24 |
| Ephydriidae                  |         | 1  |    |
| Forcipomyiinae               |         |    | 12 |
| <i>Glyptotendipes</i>        |         | 5  | 10 |
| <i>Harnischia</i>            | 1       |    |    |
| <i>Labrundinia</i>           |         | 1  | 1  |
| <i>Microtendipes</i>         | 2       |    |    |

| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| <i>Nanocladius</i>                |         |    | 1  |
| <i>Nilothauma</i>                 | 1       |    |    |
| <i>Parachironomus</i>             |         | 2  |    |
| <i>Parakiefferiella</i>           |         |    | 1  |
| <i>Paralauterborniella</i>        | 4       |    |    |
| <i>Paratanytarsus</i>             | 1       | 5  | 2  |
| <i>Phaenopsectra</i>              | 2       | 1  |    |
| <i>Polypedilum illinoense</i> grp |         | 3  | 1  |
| <i>Polypedilum scalaenum</i> grp  |         | 1  | 2  |
| <i>Polypedilum tritum</i>         |         |    | 1  |
| <i>Procladius</i>                 | 23      | 2  | 1  |
| <i>Pseudochironomus</i>           |         | 2  | 15 |
| <i>Rheotanytarsus</i>             | 1       | 4  |    |
| <i>Stelechomyia</i>               |         |    | 5  |
| <i>Stempellinella</i>             |         | 1  |    |
| <i>Stenochironomus</i>            |         | 1  | 9  |
| <i>Tanytarsus</i>                 | 21      | 42 | 31 |
| <i>Thienemanniella</i>            |         |    | 1  |
| <i>Thienemannimyia</i> grp.       |         | 8  | 17 |
| <i>Tribelos</i>                   | 1       |    | 11 |
| <i>Zavrelimyia</i>                |         |    | 1  |
| EPHEMEROPTERA                     |         |    |    |
| <i>Caenis anceps</i>              | 6       |    |    |
| <i>Caenis latipennis</i>          | 41      |    | 2  |
| <i>Stenacron</i>                  | 15      | 2  | 10 |
| <i>Stenonema femoratum</i>        | 24      | 1  |    |
| HAPLOTAXIDA                       |         |    |    |
| <i>Haplotaxis</i>                 | 1       |    |    |
| HEMIPTERA                         |         |    |    |
| <i>Belostoma</i>                  |         | 1  |    |
| Corixidae                         | 1       |    |    |
| <i>Rheumatobates</i>              |         | 1  |    |
| ISOPODA                           |         |    |    |
| <i>Caecidotea</i>                 |         | 7  |    |
| ODONATA                           |         |    |    |
| <i>Argia</i>                      | 1       | 19 | 8  |
| <i>Enallagma</i>                  | 1       | 33 |    |
| RHYNCHOBDELLIDA                   |         |    |    |
| Glossiphoniidae                   |         | 1  |    |
| TRICHOPTERA                       |         |    |    |
| <i>Cheumatopsyche</i>             |         | 1  |    |

| Taxa                            | Habitat |    |    |
|---------------------------------|---------|----|----|
|                                 | NF      | RM | SG |
| <i>Hydroptila</i>               |         |    | 2  |
| <i>Oecetis</i>                  | 1       |    |    |
| TRICLADIDA                      |         |    |    |
| Planariidae                     |         | 1  |    |
| TUBIFICIDA                      |         |    |    |
| <i>Limnodrilus hoffmeisteri</i> | 2       |    |    |
| Tubificidae                     | 59      | 1  | 4  |
| VENEROIDA                       |         |    |    |
| <i>Corbicula</i>                | 1       | 8  | *  |
| Pisidiidae                      | 6       | 19 |    |

## **Appendix B**

Spring 2016 Macroinvertebrate Taxa Lists

Muddy Creek

Kick net collections of macroinvertebrates from Muddy Creek station 1 (MC1), Pettis County, Missouri in the spring 2016. \* = taxon found in large and rare; Habitats: CS=course substrate, NF=nonflow, RM=rootmat.

| Taxa                           | Habitat |    |    |
|--------------------------------|---------|----|----|
|                                | NF      | RM | SG |
| "HYDRACARINA"                  |         |    |    |
| Acarina                        | 16      | 19 | 1  |
| AMPHIPODA                      |         |    |    |
| <i>Crangonyx</i>               |         | 4  |    |
| <i>Hyalella azteca</i>         |         |    | 1  |
| BASOMMATOPHORA                 |         |    |    |
| Ancylidae                      |         | 2  |    |
| <i>Physella</i>                | 1       | 8  | 1  |
| COLEOPTERA                     |         |    |    |
| <i>Ancyronyx variegatus</i>    | 2       | 2  |    |
| <i>Berosus</i>                 | 1       | 3  |    |
| <i>Dubiraphia</i>              |         | 4  |    |
| Dytiscidae                     |         |    | 1  |
| <i>Macronychus glabratus</i>   |         | 2  |    |
| Scirtidae                      |         | 1  |    |
| <i>Stenelmis</i>               | 1       | 2  |    |
| DECAPODA                       |         |    |    |
| <i>Faxonius luteus</i>         | *       |    |    |
| <i>Faxonius virilis</i>        |         | 1  |    |
| DIPTERA                        |         |    |    |
| <i>Ablabesmyia</i>             | 4       | 4  | 2  |
| Ceratopogoninae                | 1       | 3  |    |
| Chironomidae                   |         |    | 2  |
| <i>Chironomus</i>              | 14      | 1  | 1  |
| <i>Cladotanytarsus</i>         | 14      | 2  | 12 |
| <i>Cricotopus/Orthocladius</i> | 16      | 18 | 52 |
| <i>Cryptochironomus</i>        | 5       |    | 2  |
| <i>Cryptotendipes</i>          | 40      |    | 9  |
| <i>Dicrotendipes</i>           | 9       | 21 | 88 |
| Diptera                        |         | 1  | 1  |
| <i>Eukiefferiella</i>          |         | 1  |    |
| <i>Hydrobaenus</i>             | 28      | 12 | 7  |
| <i>Labrundinia</i>             |         | 6  |    |
| <i>Limnophila</i>              |         | 1  |    |
| <i>Micropsectra</i>            |         |    | 1  |
| <i>Nilothauma</i>              | 1       |    |    |
| <i>Parakiefferiella</i>        | 19      | 8  | 13 |
| <i>Paralauterborniella</i>     | 16      | 1  | 3  |



| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| <i>Paratanytarsus</i>             |         | 2  |    |
| <i>Paratendipes</i>               | 9       | 2  | 6  |
| <i>Phaenopsectra</i>              | 3       | 6  | 2  |
| <i>Polypedilum flavum</i>         |         | 2  |    |
| <i>Polypedilum halterale</i> grp  | 6       | 1  |    |
| <i>Polypedilum illinoense</i> grp | 1       | 29 | 9  |
| <i>Polypedilum scalaenum</i> grp  | 5       | 4  | 15 |
| <i>Procladius</i>                 | 4       |    |    |
| <i>Pseudochironomus</i>           |         |    | 1  |
| <i>Rheotanytarsus</i>             |         | 11 | 8  |
| <i>Stenochironomus</i>            |         | 1  |    |
| <i>Tanytarsus</i>                 | 9       | 83 | 72 |
| <i>Telopelopia</i>                |         |    | 1  |
| <i>Thienemanniella</i>            | 1       | 1  | 3  |
| <i>Thienemannimyia</i> grp.       | 3       | 31 | 4  |
| EPHEMEROPTERA                     |         |    |    |
| <i>Acerpenna</i>                  |         | 1  |    |
| <i>Caenis latipennis</i>          | 7       | 4  | 2  |
| <i>Fallceon</i>                   |         |    | 1  |
| <i>Stenacron</i>                  | 1       |    |    |
| <i>Stenonema femoratum</i>        | 2       | *  | 1  |
| <i>Tricorythodes</i>              |         | 2  | 2  |
| ISOPODA                           |         |    |    |
| <i>Lirceus</i>                    |         | 1  |    |
| ODONATA                           |         |    |    |
| <i>Argia</i>                      | *       | 5  |    |
| <i>Basiaeschna janata</i>         |         | *  |    |
| <i>Dromogomphus</i>               | *       |    |    |
| <i>Enallagma</i>                  |         | 1  |    |
| <i>Nasiaeschna pentacantha</i>    |         | 1  |    |
| TRICHOPTERA                       |         |    |    |
| <i>Cheumatopsyche</i>             |         | 3  |    |
| <i>Hydroptila</i>                 | 1       | 3  | 3  |
| TRICLADIDA                        |         |    |    |
| Planariidae                       |         | 1  |    |
| TUBIFICIDA                        |         |    |    |
| <i>Limnodrilus claparedianus</i>  | 1       |    |    |
| <i>Limnodrilus hoffmeisteri</i>   | 5       |    |    |
| Tubificidae                       | 12      | 4  |    |
| VENEROIDA                         |         |    |    |

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| Taxa             | Habitat |    |    |
|------------------|---------|----|----|
|                  | NF      | RM | SG |
| <i>Corbicula</i> | 1       | 3  |    |

Kick net collections of macroinvertebrates from Muddy Creek station 2 (MC2), Pettis County, Missouri in the spring 2016. \* = taxon found in large and rare; Habitats: CS=course substrate, NF=nonflow, RM=rootmat.

| Taxa                           | Habitat |    |     |
|--------------------------------|---------|----|-----|
|                                | NF      | RM | SG  |
| "HYDRACARINA"                  |         |    |     |
| Acarina                        | 4       | 10 | 2   |
| AMPHIPODA                      |         |    |     |
| <i>Crangonyx</i>               |         | 16 |     |
| <i>Hyalella azteca</i>         |         | 3  |     |
| ARHYNCHOBDELLIDA               |         |    |     |
| Erpobdellidae                  | *       |    |     |
| BASOMMATOPHORA                 |         |    |     |
| Ancylidae                      | 1       | 1  |     |
| <i>Physella</i>                | 3       | 11 | 8   |
| COLEOPTERA                     |         |    |     |
| <i>Ancyronyx variegatus</i>    |         | 2  | 1   |
| <i>Berosus</i>                 |         | 2  |     |
| <i>Dubiraphia</i>              |         | 2  |     |
| <i>Peltodytes</i>              |         |    | 1   |
| <i>Stenelmis</i>               |         | 4  |     |
| DIPTERA                        |         |    |     |
| <i>Ablabesmyia</i>             |         | 1  |     |
| <i>Anopheles</i>               |         | 1  |     |
| Ceratopogoninae                | 16      | 3  |     |
| Chironomidae                   | 5       | 1  | 2   |
| <i>Chironomus</i>              | 17      |    | 1   |
| <i>Cladotanytarsus</i>         | 14      | 1  | 4   |
| <i>Corynoneura</i>             |         | 1  | 1   |
| <i>Cricotopus bicinctus</i>    |         |    | 3   |
| <i>Cricotopus/Orthocladius</i> | 71      | 69 | 167 |
| <i>Cryptochironomus</i>        | 4       | 2  | 1   |
| <i>Cryptotendipes</i>          | 5       |    |     |
| <i>Dicrotendipes</i>           | 2       | 8  | 76  |
| Diptera                        | 1       |    |     |
| <i>Eukiefferiella</i>          | 7       | 1  | 12  |
| <i>Hydrobaenus</i>             | 66      | 15 | 12  |
| <i>Labrundinia</i>             | 1       | 3  |     |
| <i>Microtendipes</i>           |         | 1  |     |
| <i>Nanocladius</i>             | 1       |    |     |
| <i>Parakiefferiella</i>        | 1       | 3  |     |
| <i>Paralauterborniella</i>     | 3       | 1  | 1   |
| <i>Paratanytarsus</i>          | 2       | 1  | 1   |

|                                   |    |    |    |
|-----------------------------------|----|----|----|
| <i>Paratendipes</i>               | 11 | 6  |    |
| <i>Phaenopsectra</i>              |    | 3  |    |
| <i>Polypedilum fallax</i> grp     |    |    | 1  |
| <i>Polypedilum flavum</i>         |    |    | 1  |
| <i>Polypedilum halterale</i> grp  | 2  |    |    |
| <i>Polypedilum illinoense</i> grp | 1  | 25 |    |
| <i>Polypedilum scalaenum</i> grp  | 15 | 6  | 6  |
| <i>Pseudochironomus</i>           |    |    | 2  |
| <i>Rheotanytarsus</i>             |    | 2  | 2  |
| <i>Simulium</i>                   |    |    | 1  |
| <i>Tanytarsus</i>                 | 7  | 60 | 24 |
| <i>Thienemanniella</i>            | 3  |    | 2  |
| <i>Thienemannimyia</i> grp.       | 1  | 24 | 3  |
| EPHEMEROPTERA                     |    |    |    |
| <i>Caenis latipennis</i>          | 2  | 8  |    |
| <i>Stenacron</i>                  |    | 1  |    |
| <i>Stenonema femoratum</i>        | 1  |    | *  |
| <i>Tricorythodes</i>              |    | 1  |    |
| LEPIDOPTERA                       |    |    |    |
| Noctuidae                         | *  |    |    |
| NEOTAENIOGLOSSA                   |    |    |    |
| Hydrobiidae                       | 1  | 1  | 1  |
| ODONATA                           |    |    |    |
| <i>Argia</i>                      |    | 2  |    |
| <i>Calopteryx</i>                 |    | 2  |    |
| <i>Enallagma</i>                  |    | 5  |    |
| <i>Nasiaeschna pentacantha</i>    |    | 4  |    |
| TRICHOPTERA                       |    |    |    |
| <i>Cheumatopsyche</i>             |    | 3  | 2  |
| <i>Hydroptila</i>                 |    | 1  | 4  |
| <i>Ironoquia</i>                  |    | 1  |    |
| <i>Nectopsyche</i>                |    | 1  |    |
| TUBIFICIDA                        |    |    |    |
| <i>Limnodrilus claparedianus</i>  | 1  |    |    |
| <i>Limnodrilus hoffmeisteri</i>   | 3  |    |    |
| Tubificidae                       | 12 | 5  |    |
| VENEROIDA                         |    |    |    |
| <i>Corbicula</i>                  | *  |    |    |
| Pisidiidae                        |    | 3  | 1  |

Kick net collections of macroinvertebrates from Muddy Creek station 3 (MC3), Pettis County, Missouri in the spring 2016. \* = taxon found in large and rare; Habitats: CS=course substrate, NF=nonflow, RM=rootmat.

| Taxa                            | Habitat |    |     |
|---------------------------------|---------|----|-----|
|                                 | NF      | RM | SG  |
| "HYDRACARINA"                   |         |    |     |
| Acarina                         | 9       | 1  | 2   |
| AMPHIPODA                       |         |    |     |
| <i>Crangonyx</i>                |         | 1  |     |
| <i>Hyalella azteca</i>          |         | 1  | 2   |
| ARHYNCHOBDELLIDA                |         |    |     |
| Erpobdellidae                   | *       | 1  |     |
| BASOMMATOPHORA                  |         |    |     |
| Ancylidae                       |         |    | 1   |
| Lymnaeidae                      |         | 5  | 1   |
| <i>Menetus</i>                  | 1       | 3  | 1   |
| <i>Physella</i>                 |         | 7  | 1   |
| COLEOPTERA                      |         |    |     |
| <i>Ancyronyx variegatus</i>     |         | 1  |     |
| <i>Berosus</i>                  |         | 1  | 2   |
| <i>Dineutus</i>                 |         | *  |     |
| <i>Dubiraphia</i>               | 1       |    |     |
| <i>Dytiscus</i>                 |         |    | *   |
| <i>Optioservus sandersoni</i>   |         |    | 2   |
| <i>Stenelmis</i>                | 3       | 2  |     |
| DECAPODA                        |         |    |     |
| <i>Faxonius virilis</i>         |         | *  |     |
| <i>Palaemonetes kadiakensis</i> |         | *  |     |
| DIPTERA                         |         |    |     |
| <i>Ablabesmyia</i>              | 2       | 3  | 1   |
| Ceratopogoninae                 | 7       |    |     |
| Chironomidae                    |         |    | 1   |
| <i>Chironomus</i>               | 6       |    | 1   |
| <i>Cladotanytarsus</i>          | 36      | 1  | 1   |
| <i>Corynoneura</i>              |         | 1  |     |
| <i>Cricotopus/Orthocladius</i>  | 8       | 76 | 210 |
| <i>Cryptochironomus</i>         | 9       | 1  | 5   |
| <i>Cryptotendipes</i>           | 63      |    | 1   |
| Dasyheleinae                    |         |    | 1   |
| <i>Dicrotendipes</i>            | 6       | 12 | 47  |
| Diptera                         | 2       |    |     |
| <i>Glyptotendipes</i>           |         |    | 2   |
| <i>Hydrobaenus</i>              | 8       | 8  | 7   |

| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| <i>Labrundinia</i>                |         | 1  |    |
| <i>Micropsectra</i>               | 2       | 1  |    |
| <i>Parakiefferiella</i>           | 1       | 4  |    |
| <i>Paralauterborniella</i>        | 7       |    |    |
| <i>Paratendipes</i>               | 6       |    | 3  |
| <i>Phaenopsectra</i>              |         | 3  | 3  |
| <i>Polypedilum halterale</i> grp  | 6       | 1  |    |
| <i>Polypedilum illinoense</i> grp |         | 4  | 2  |
| <i>Polypedilum scalaenum</i> grp  | 11      | 1  | 15 |
| <i>Procladius</i>                 | 1       |    |    |
| <i>Rheotanytarsus</i>             | 1       | 13 | 1  |
| <i>Stenochironomus</i>            |         |    | 1  |
| <i>Tanytarsus</i>                 | 19      | 47 | 35 |
| <i>Thienemanniella</i>            |         | 7  | 2  |
| <i>Thienemannimyia</i> grp.       | 1       | 25 | 10 |
| <i>Tipula</i>                     |         | *  |    |
| EPHEMEROPTERA                     |         |    |    |
| <i>Caenis latipennis</i>          | 1       | 1  |    |
| <i>Hexagenia limbata</i>          | 1       |    |    |
| <i>Stenacron</i>                  | 1       |    |    |
| <i>Stenonema femoratum</i>        | 1       | *  | 1  |
| <i>Tricorythodes</i>              |         | 1  |    |
| HEMIPTERA                         |         |    |    |
| <i>Belostoma</i>                  |         | *  |    |
| LEPIDOPTERA                       |         |    |    |
| Noctuidae                         |         |    | *  |
| LUMBRICULIDA                      |         |    |    |
| Lumbriculidae                     |         | *  |    |
| NEOTAENIOGLOSSA                   |         |    |    |
| Hydrobiidae                       |         | 5  | 2  |
| ODONATA                           |         |    |    |
| <i>Argia</i>                      |         | 3  |    |
| <i>Calopteryx</i>                 |         | 2  |    |
| <i>Enallagma</i>                  |         | 3  |    |
| <i>Ischnura</i>                   |         |    | *  |
| <i>Nasiaeschna pentacantha</i>    |         | *  |    |
| TRICHOPTERA                       |         |    |    |
| <i>Cheumatopsyche</i>             | 1       | 17 | 1  |
| <i>Hydroptila</i>                 |         |    | 1  |
| <i>Ironoquia</i>                  |         | *  | *  |
| TRICLADIDA                        |         |    |    |

| Taxa                             | Habitat |    |    |
|----------------------------------|---------|----|----|
|                                  | NF      | RM | SG |
| Planariidae                      |         | 2  |    |
| TUBIFICIDA                       |         |    |    |
| <i>Limnodrilus claparedianus</i> | 4       |    |    |
| <i>Limnodrilus hoffmeisteri</i>  | 4       | 1  |    |
| <i>Limnodrilus udekemianus</i>   | 1       |    |    |
| Tubificidae                      | 102     |    | 2  |
| VENEROIDA                        |         |    |    |
| Pisidiidae                       | 2       | 10 |    |

Kick net collections of macroinvertebrates from Muddy Creek station 4 (MC4), Pettis County, Missouri in the spring 2016. \* = taxon found in large and rare; Habitats: CS=course substrate, NF=nonflow, RM=rootmat.

| Taxa                            | Habitat |    |    |
|---------------------------------|---------|----|----|
|                                 | NF      | RM | SG |
| "HYDRACARINA"                   |         |    |    |
| Acarina                         | 87      | 20 | 50 |
| AMPHIPODA                       |         |    |    |
| <i>Crangonyx</i>                |         | 5  |    |
| <i>Hyalella azteca</i>          |         | 14 | 3  |
| ARHYNCHOBDELLIDA                |         |    |    |
| Erpobdellidae                   | *       | *  |    |
| BASOMMATOPHORA                  |         |    |    |
| Ancylidae                       |         | 3  |    |
| <i>Menetus</i>                  |         | 12 | 1  |
| <i>Physella</i>                 |         | 20 |    |
| BRANCHIOBDELLIDA                |         |    |    |
| Branchiobdellida                | 2       | 1  |    |
| COLEOPTERA                      |         |    |    |
| <i>Ancyronyx variegatus</i>     |         | 3  |    |
| <i>Berosus</i>                  | 1       | 2  |    |
| <i>Dubiraphia</i>               | 2       | 3  | 3  |
| Dytiscidae                      | 1       |    | 1  |
| <i>Dytiscus</i>                 |         | 1  |    |
| <i>Macronychus glabratus</i>    |         |    | 1  |
| <i>Neoporus</i>                 |         | 1  |    |
| <i>Stenelmis</i>                | 2       | 6  |    |
| DECAPODA                        |         |    |    |
| <i>Faxonius luteus</i>          | *       |    |    |
| <i>Faxonius virilis</i>         | *       | *  |    |
| <i>Palaemonetes kadiakensis</i> | *       |    |    |
| DIPTERA                         |         |    |    |
| <i>Ablabesmyia</i>              | 2       | 5  |    |
| Ceratopogoninae                 | 12      | 4  | 5  |
| Chironomidae                    | 5       | 2  | 1  |
| <i>Chironomus</i>               | 1       |    |    |
| <i>Cladotanytarsus</i>          | 27      |    | 17 |
| <i>Cricotopus bicinctus</i>     |         | 1  | 1  |
| <i>Cricotopus/Orthocladius</i>  | 6       | 78 | 71 |
| <i>Cryptochironomus</i>         | 1       |    |    |
| <i>Cryptotendipes</i>           | 28      |    | 7  |
| <i>Dicrotendipes</i>            | 2       | 5  | 30 |
| <i>Diplocladius</i>             | 1       | 1  |    |



| Taxa                              | Habitat |    |    |
|-----------------------------------|---------|----|----|
|                                   | NF      | RM | SG |
| Diptera                           |         | 1  | 1  |
| <i>Eukiefferiella</i>             |         | 4  | 7  |
| <i>Glyptotendipes</i>             |         | 10 | 3  |
| <i>Hydrobaenus</i>                | 36      | 4  | 4  |
| <i>Labrundinia</i>                | 1       | 2  |    |
| <i>Nanocladius</i>                |         | 1  |    |
| <i>Nilothauma</i>                 |         |    | 1  |
| <i>Ormosia</i>                    | 1       |    | 1  |
| <i>Parachironomus</i>             |         | 1  |    |
| <i>Parakiefferiella</i>           |         | 9  |    |
| <i>Paratanytarsus</i>             | 2       | 2  | 2  |
| <i>Paratendipes</i>               | 2       | 1  | 1  |
| <i>Phaenopsectra</i>              |         | 1  |    |
| <i>Polypedilum flavum</i>         |         | 1  | 1  |
| <i>Polypedilum halterale</i> grp  | 4       |    | 1  |
| <i>Polypedilum illinoense</i> grp | 1       | 15 |    |
| <i>Polypedilum scalaenum</i> grp  | 4       | 1  | 5  |
| <i>Procladius</i>                 | 6       |    | 1  |
| <i>Prosimulium</i>                |         |    | 1  |
| <i>Pseudochironomus</i>           |         |    | 5  |
| <i>Rheotanytarsus</i>             |         | 1  |    |
| <i>Simulium</i>                   |         |    | 5  |
| <i>Stempellina</i>                |         |    | 1  |
| <i>Stenochironomus</i>            |         |    | 4  |
| <i>Tanytarsus</i>                 | 12      | 31 | 40 |
| <i>Thienemanniella</i>            |         | 1  |    |
| <i>Thienemannimyia</i> grp.       |         | 2  | 4  |
| <i>Tribelos</i>                   |         |    | 3  |
| EPHEMEROPTERA                     |         |    |    |
| <i>Caenis latipennis</i>          | 8       | 5  |    |
| <i>Stenacron</i>                  | 4       | 1  |    |
| <i>Stenonema femoratum</i>        | 2       | 1  | *  |
| HEMIPTERA                         |         |    |    |
| <i>Ranatra fusca</i>              |         | *  |    |
| ISOPODA                           |         |    |    |
| <i>Caecidotea</i>                 |         | 2  |    |
| <i>Lirceus</i>                    |         | 1  |    |
| LEPIDOPTERA                       |         |    |    |
| Noctuidae                         | 1       |    |    |
| NEOTAENIOGLOSSA                   |         |    |    |
| Hydrobiidae                       |         | 3  | 1  |

| Taxa                             | Habitat |    |    |
|----------------------------------|---------|----|----|
|                                  | NF      | RM | SG |
| ODONATA                          |         |    |    |
| <i>Argia</i>                     |         | 1  |    |
| <i>Calopteryx</i>                |         | 1  |    |
| <i>Enallagma</i>                 |         | 13 |    |
| TRICHOPTERA                      |         |    |    |
| <i>Chimarra</i>                  |         | 1  |    |
| <i>Hydroptila</i>                |         | 1  | 1  |
| TUBIFICIDA                       |         |    |    |
| <i>Branchiura sowerbyi</i>       | 1       |    |    |
| Enchytraeidae                    |         | 1  |    |
| <i>Limnodrilus claparedianus</i> | 1       |    |    |
| <i>Limnodrilus hoffmeisteri</i>  | 1       | 1  |    |
| Tubificidae                      | 33      |    | 2  |
| VENEROIDA                        |         |    |    |
| Pisidiidae                       |         | 2  |    |